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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 124.

B. T. GALLOWAY, *Chief of Bureau.*

THE PRICKLY PEAR AS A FARM CROP.

BY

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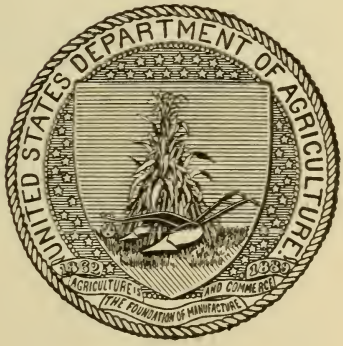

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief.
Washington, D. C., December 6, 1907.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 124 of the series of this Bureau, a manuscript entitled "The Prickly Pear as a Farm Crop," by Dr. David Griffiths, which has been submitted by Prof. W. J. Spillman, Agriculturist in Charge of Farm Management Investigations, with a view to publication.

This is the first report based upon actual experiments dealing with the cultivation upon a field basis of any of the peculiar and interesting plants known as prickly pears. They have been utilized to a large extent in the economy of the stock business of southern Texas, but have never before been cultivated as a field crop in this country.

The author desires to acknowledge his indebtedness in the conduct of these investigations to the cooperation of Mr. Alexander Sinclair, upon whose ranch the work is being carried on, and to his son, Mr. William Sinclair, who has so faithfully cared for the plantation.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE PRICKLY PEAR AS A FARM CROP.

INTRODUCTION.

No attempts have been made hitherto to cultivate prickly pear as a regular crop in this country. The nearest approach to it was made by some of the old mission fathers of California, who imported cuttings, probably from Mexico, and planted them in hedges, where they served the double purpose of barriers against stock and as food for man. That they received any appreciable degree of cultivation, however, is very doubtful. They were probably grown in much the same manner that the so-called cultivated prickly pears are grown in Mexico to-day.

An extended use has been made of the native crop at various times for the past fifty years or more in southern Texas, but it has mainly been spasmodic, lasting only until "the drought was broken," except for sheep and goats, which are fed on it regularly, and in the case of the few dairymen who have made it a practice to feed it for a portion of each year. In short, the prickly pear has been considered an emergency feed, to be used only when other feeds fail. Even enthusiastic pear feeders in Texas thought that the results to be obtained from planting and cultivating an experimental tract would only be "very interesting." There was little expectation that the plants would respond to cultivation as they have done. The facts presented in this paper, however, show that the prickly pear will produce, under proper cultural methods similar to those used for the common staple crops, yields of roughage superior to some of the standard agricultural crops of the region, especially when an off year occurs. It has proved itself under cultivation not only an emergency feed but an insurance against famine, as well as a plant which can be grown and depended upon regularly as a farm crop.

The investigations of this subject at the present time are very opportune indeed, because the demand for such a crop is not as great in southern Texas now as in a thickly settled region, giving ample time for growers to learn just the position that the crop should occupy in the economy of their operations. Land is still changing

hands in southern Texas in 200-section blocks, and all of it has more or less prickly pear growing upon it. It is not to be expected that holders of such areas will be concerned with the culture of prickly pear any more than they will be concerned with the culture of any other crop, for they have plenty of pear growing wild in their pastures now, often more than they can possibly use. Settlement and subdivision of holdings are taking place very rapidly, however, throughout the region, and the time is not far distant when the whole country will be divided up into small holdings where the small farmer will depend upon a variety of crops and where use will be found for a crop like this which can withstand a protracted drought of two or three months or more without artificial irrigation.

Indeed, many large communities now exist which need to grow some crop of this kind. In the vicinity of the larger cities dairymen have for years been in great need of roughage upon which they can depend, as well as succulent feed, which is not usually available during one-half of the year. In the vicinity of San Antonio, Tex., the feeding of the prickly pear has been so extensive during the past six years that the pastures have been practically depleted of it within a radius of eight miles from the city. Still, the hauling of the crop such distances is doubtfully profitable, especially when it must now almost invariably be paid for. When it is remembered that a cow will eat in the neighborhood of 100 pounds a day, it will be readily understood that to haul pear such distances for feed is very burdensome. These dairymen could much better afford to turn some of their native brush pastures into cultivated fields of prickly pear, wherein they could feed the crop with no handling and be insured against a shortage of roughage. The conditions around San Antonio are practically duplicated near Laredo.

Attention should be called here to the fact that this report applies to the experiments conducted at San Antonio only and that the territory to which the experiments apply extends, roughly, from Houston to Del Rio and from Austin to Brownsville. Investigations along similar lines are being conducted in New Mexico, Arizona, California, and Florida, but it is not time to report upon them yet.

CLIMATIC CONDITIONS OF THE REGION.

According to Bulletin Q, "Climatology of the United States," issued by the United States Weather Bureau, the mean annual precipitation for the city of San Antonio for the past eighteen years has been 28.4 inches. The total amount for the driest year for the same period was 15.9 inches, and the total for the wettest year, 40.5. These figures are very important in the interpretation of these investigations and show that the work is being done in a region of relatively high average annual rainfall. These tables do not, however,

tell the whole story. It is necessary to study the monthly totals in order to appreciate the conditions of moisture prevailing. The following table is compiled from monthly totals of precipitation for the past ten years and shows in a striking way how irregular is the distribution of moisture:

TABLE I.—*Monthly totals of precipitation for San Antonio, Tex., for the ten years from 1897 to 1906, inclusive, in inches.*

Month.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Monthly extremes.
January	1.59	0.46	0.38	5.42	0.41	0.70	2.39	0.30	0.88	0.29	0.30 to 5.42
February	15	1.16	.31	.34	.71	.55	7.88	.64	1.62	1.07	.15 to 7.88
March	1.65	1.47	*T.	4.34	.54	.12	1.29	.16	2.74	1.29	*T. to 4.34
April	1.84	1.46	2.60	9.11	.59	2.31	1.74	3.25	6.08	3.94	.59 to 9.11
May	3.13	1.06	2.22	4.47	2.47	3.14	1.95	5.93	4.11	.86	1.06 to 5.93
June	2.19	7.06	4.32	78	1.86	.02	4.75	1.73	6.01	.62	.02 to 7.06
July	.28	2.24	2.85	2.24	3.79	3.85	7.52	3.50	2.82	4.34	.28 to 7.52
August	.40	3.35	.00	4.05	.96	.00	.20	1.97	.51	2.25	.00 to 4.05
September	1.61	1.32	.57	.97	4.20	5.52	2.96	7.74	1.80	1.74	.57 to 7.47
October	1.35	.03	1.31	2.94	.12	2.54	1.61	2.86	1.83	1.09	.03 to 2.94
November	.43	1.34	1.70	1.82	.64	3.53	*T	.24	2.63	1.33	*T. to 3.53
December	1.34	1.54	3.39	.70	.15	2.51	.82	1.06	1.56	1.60	.15 to 3.39

* T.= trace.

With an equitable distribution of the rainfall there would be less demand for a crop which can withstand periods of drought.

The column showing monthly extremes in the table above is most striking; only three months have a minimum of more than one-half inch. A glance at the columns of monthly totals will show nearly as striking variations for the seasons. Even this table does not tell the complete story. One must take into consideration the torrential character of the summer rains. A rainfall of 4 inches is not at all uncommon and may occur over a very local area.

These are the moisture conditions especially adapted to the successful growth of prickly pear. Attention is called to this especially because of the apparently well-established idea in the popular mind that the plants will grow with little or no water—i. e., are adapted to any desert condition. On the contrary, they are adapted to grow where the rainfall is considerable but irregularly or periodically distributed. These plants can not grow without water any more than any others, but they can get along for long periods without it on account of the large quantities which they store up in their succulent tissues.

As regards temperature[a] we are concerned with this crop mainly in the minimum. The lowest temperature recorded by the Weather

[a] The records are all compiled from the United States Weather Bureau records in the city of San Antonio, which are not perfectly satisfactory for our station, because it is not only 8 miles distant, but 79 feet above the ground, and consequently may not represent conditions where the plants grow within several degrees. These records, however, are the only ones available.

Bureau for the San Antonio station is 4° F. in February, 1899, at which time, according to the best information obtainable, pear as well as the huisache (*Acacia farnesiana*) was badly frozen all over southern Texas. This is an unusual temperature and has occurred but once since the establishment of the station. The minimum in 1905, the lowest since these investigations were begun, occurred on February 13, when a temperature of 13° F. was reached. Even this was considered an unusually cold season. At this time the native prickly pear appeared to be near the limit of its perfect endurance. A few plants in the open drooped a little, but no permanent injury was done, as they straightened up again in a short time. The minimum Fahrenheit readings recorded for San Antonio for ten consecutive years, beginning with 1906, are as follows: 24°, 13°, 22°, 19°, 26°, 15°, 19°, 4°, 20°, 18°, 27°, and 11°. But even these temperatures are of short duration. It is seldom that seven days occur during an entire winter with an absolute minimum below 22° F. Winters are rather frequent when this temperature is not reached.

Besides a minimum not lower than something like 12° F. a high average summer temperature is an advantage in the culture of prickly pear. During the ten years ending in 1903 there occurred on an average only four days a year with a maximum over 100° F. One year of this period had twelve days with a maximum above 100° F. and one year's maximum did not reach 100° F. The conditions in this respect are presented in the following table:[a]

TABLE II.—*Maximum, minimum, and mean temperatures at San Antonio, Tex., for a period of eighteen and one-half years, 1888 to 1906, inclusive.*

Month.	Mean.	Maximum.	Minimum.	Month.	Mean.	Maximum.	Minimum.
	°F.	°F.	°F.		°F.	°F.	°F.
January	52	82	6	July	83	106	64
February	55	90	4	August	83	103	57
March	62	97	21	September	78	100	46
April	70	99	35	October	70	97	37
May	75	97	44	November	60	90	22
June	81	103	54	December	55	86	15

PREPARATION OF CUTTINGS OF PRICKLY PEAR.

When these investigations were begun certain conventional formulæ for planting all species of cacti were more or less in vogue. These were found in the practices of horticulturists and in published reports, mainly of French investigators in northern Africa. These practices, briefly summarized, related mainly to propagation from cuttings. It has been the custom among horticulturists, as well as the practice of the growers mentioned above, to prepare the

[a] See also discussions of temperature on page 21.

cuttings some time, commonly two weeks, before planting them. In other words, the joints were somewhat wilted before being planted. This practice appears to be necessary under greenhouse conditions, and growers in northern Africa seem to be quite insistent upon the same practice for out-of-door culture. When planted under the humid conditions of the greenhouse, cuttings are much more likely to decay at the surface of the ground unless some of the moisture is evaporated before the cut surface is put in contact with moist earth.

Prickly pear cuttings do not callous over and produce roots from the cambium and buds as do cuttings from ordinary trees and shrubs, but the cut surface heals over and roots are put forth from the areoles which contain the spines. It is important to bear this in mind in the propagation of the prickly pears. From the greenhouse standpoint it is necessary that the cut surface be thoroughly dried before the cutting is set.

Some attention was paid to this practice when the first plantings were made in the spring of 1905. An attempt was made to prepare the cuttings at least forty-eight hours before they were planted, but it was not always done. Indeed, a considerable part of the planting occurred immediately after the cuttings were prepared. No bad effect was observed from the practice followed, although some of the cuttings were planted during a very wet season. Since that time no attention has been paid to the wilting of the cuttings.

The practice has been to use one-joint cuttings almost entirely for planting, and it is believed that this is the most advantageous, all things considered, for commercial practice. The favorite instrument for making the cuttings has been a hoe straightened out so that the blade is in a straight line with the handle. This is used much as a spade might be used for the same purpose. With this instrument the whole plant is cut up, as nearly as is convenient, into individual joints. Of course it is not always convenient or even possible to strike the union between the joints exactly, but this is approximated as closely as possible. Sometimes the instrument severs one side or the other, but this appears to make little difference, if any.

When the 6 acres of ground were planted in the spring of 1907, it was done with the avowed purpose of performing the work as it was considered the practical farmer or dairyman would carry it on. It was the intention to get as practical a test as possible. The plants after being brought to the field were cut up into single joints mainly by the writer, but the hauling and distributing of the cuttings were done principally by negro and Mexican labor. The handling was done entirely with pitchforks, and the laborers were not cautioned at all about being careful not to injure the stock. As a result, practically every joint planted upon the entire 6 acres had from one to a half

dozen tine holes in it. In spite of this, it is certain that at least 99 per cent of the cuttings grew. Indeed, the stand on all portions of the field was practically perfect.

The above experience is cited to show that there is nothing impracticable in our method of rough handling of the cuttings, not as a justification of such handling. The less injury the cuttings receive the better they will grow and the more vigorous plants will they make without doubt; but it is by no means imperative that care to the sacrifice of speed in handling should be indulged in. The cuttings will withstand quite rough treatment and still make good plants, but they should not be unnecessarily bruised or mangled.

As has been stated, single-joint cuttings have been used as a rule. Occasionally when joints were very small two of them have been left attached. The whole plant has been used invariably. All the joints appear to grow equally well, but large, heavy joints two or more years old make much the best plants. Good plants are always obtained from old woody stems, often six or seven years old. These are also much less likely to be bruised and otherwise injured in handling than the younger growth.

The Mexican people who handle very small quantities commonly plant two and a half to three joint cuttings. Their object is to get fruit as early as possible. In the cultivation of their large tame forms they are not concerned with the stock-feed side of the question. They claim to get a good crop of fruit the third year from such cuttings, while it would take five years to secure the same crop from single-joint cuttings. Good crops of fruit have been secured from single-joint cuttings of the native *Opuntia lindheimeri* in three years in southern Texas. The large tame forms of Mexico are much larger plants, and it may consequently take them longer to come into bearing. Indeed, none of them grown from single-joint cuttings alongside of the Texas forms produced fruit in any quantity the third year.

METHOD OF PLANTING.

There are many points connected with the various operations of planting, cultivating, and handling of these plants that have not been fully demonstrated as yet. The best that can be done in connection with some of these processes is to give an account of the methods which have been used in these experiments. It is expected, of course, that these will be improved upon as our experience in growing prickly pear becomes more extensive.

When the cultural work was taken up a 6-foot row was decided upon as the most suitable. The distance between the cuttings in the row has been varied from 2 to 4 feet. Although plantings have been made for the purpose of determining which is the best distance,

still it is not possible to make any definite recommendations at the present time any more than to say that close planting appears to be more productive in a general way than the more distant planting. So thoroughly did this appear to be the case in our first experiments that the entire 6 acres planted in the spring of 1907 had cuttings planted 2 feet apart, from center to center, in 6 or 8 foot rows.

It is recommended to those who contemplate the cultivation of this crop for forage in southern Texas that 6-foot rows be adopted and that the cuttings be set 2 feet apart, from center to center, in the row. This will enable one to cultivate one way for two seasons, and the crop if harvested at the end of this time can be cultivated again for the succeeding two seasons, when the second crop is being grown, and so on indefinitely. It will be difficult to get a horse through 6-foot rows after the second year. It is quite possible that further experience will demonstrate that other distances will be more advantageous. It may be that 2 feet apart in the row will bring the plants too close together to produce the maximum yield, or that the red spider will prove less injurious when the plants are grown farther apart. These are questions which will require practice to fully demonstrate. At present it appears that 2 by 6 feet is the proper distance.

The stock planted has been secured from native pastures within a radius of 2 miles from the experiments. The plants cut off at or near the ground have been loaded on wagons with pitchforks. Sometimes the larger plants have been cut up somewhat to facilitate handling. Wagonloads of stock of this kind have been distributed in the field in piles (see Pl. I, fig. 3), which were subsequently prepared for planting by cutting the plants into individual joints with a hoe straightened upon its handle as described elsewhere. The cuttings were then distributed with a pitchfork to the places where they were to grow. Much labor can be saved by a careful distribution of the material so that it need not be carried far.

Several methods of setting the cuttings have been tested. In the earlier plantings some were set on edge in furrows or in holes opened up with a shovel. This hand labor was very expensive and troublesome, and it was soon recognized that it would not do for commercial practice. In the last plantings made the cuttings were not touched by hand at all. A portion of the 6-acre tract planted in 1907 was laid out in rows by running a shallow furrow with a small walking plow. The cuttings were laid against the furrow, the base reaching nearly to the bottom of the depression (Pl. I, fig. 3). Another furrow was then turned in the same direction, throwing dirt over the bases of these joints, covering ap-

proximately one-half of them, sometimes more and sometimes less.[a] (Pl. I, fig. 2.) Another portion of the field was simply marked and the joints were laid on the surface of the ground at proper distances in the rows thus laid out. (Pl. I, fig. 4.)

When the ground is very dry, cloddy, or otherwise poorly prepared, it will be advantageous to partially cover the cuttings; but if the ground is well pulverized and in such condition that moisture will be brought to the surface by capillarity, just as good results will be secured by simply placing the cuttings on their sides in firm contact with the ground. Indeed, in the first plantings better plants were secured in this way than when the joints were planted on edge.

There is good reason for this. Attention has been called to the fact that roots spring from the areoles or cushions of spines and spicules distributed regularly over the surface of the stems (joints). This statement is equally true of the new growth. It always springs from these areoles, but these spaces are always more numerous around the edges of the disk-like cuttings. When the cuttings are laid flat on the ground it is but a short time before unequal evaporation from the two surfaces causes them to dish slightly. This will leave the areoles in the center of the lower surface in contact with the ground. They will form roots in a very short time. From any portion of the slightly upturned edge of the joint new growth may take place. In the case of joints buried 6 inches or more by the plow, or otherwise, the surface for new growth is reduced at least by one-half and the base or foundation of the plant is also reduced, or, more properly, is much smaller than when the cutting is laid flat and the whole edge is in position to send out new growth.

It is very fortunate that the plants grow readily in this position, for planting in this way greatly reduces the labor involved. Usually all that is necessary is to drop the cutting into place from the fork. At other times it may be necessary to press it down with the foot or a slight pressure of the fork after it is in place. It should be borne in mind that the cuttings should be in contact with the ground. If they are held away from it an inch or so by clods, or even by the long, stout spines found in some of the varieties, the chances of their becoming established are greatly reduced. Indeed, if none of the areoles is in actual contact with moist earth the cuttings will not grow.

TIME OF YEAR TO PLANT.

There are indeed few, if any, crops which have such a range of adaptability as regards the time at which they may be planted. Be-

[a] Care must be taken not to cover the joints, for they will almost invariably rot if this is done.

ginning with February, 1905, plantings were made between the first and tenth of each calendar month, except August, for the next twelve months, to determine, if possible, the most favorable season. No plantings were made in August because it was excessively dry and hot, similar to July, when cuttings failed to grow. All other plantings grew as well at one season of the year as another. All of the plantings, except a part of those made in February, were upon uncultivated ground, the joints being placed in a furrow and partially covered, as described elsewhere. This feature is again a decided advantage, for it enables the farmer to plant this crop at almost any time of the year. In other words, it can be done during a season when other farm operations are not pressing. There is little doubt that cuttings will grow even in July and August, provided those months happen to be sufficiently moist.

RENEWAL OF PLANTATION.

Little is known about the length of time during which a plantation will grow when repeatedly harvested in a systematic manner. No reliable data are available. The nearest approach is in the case of the planting made by Mr. D. M. Poor (Pl. II, fig. 3). This plantation, consisting of two-thirds of an acre, was established by Mr. Poor about 1885. He laid off the ground in rows 2 feet apart, with an ordinary two-horse plow, in land which had been cleared of brush but never broken. Native pear was chopped up into one or two joint cuttings, distributed in the furrows, and subsequently partly covered with another furrow. The area has been used more or less for twenty years, but it has never been cultivated. It has never been harvested closely and certainly never systematically.

A plantation well established and cultivated is good for an indefinite period, say fifteen or twenty years. Should plants in various portions of the field die for some reason, it is a very simple matter to establish new ones when the crop is on the ground. All that is necessary is to cut off a joint and put it in the proper place flat on the ground.

CULTIVATION.

Upon the subject of cultivation little need be said. The ground to receive the cuttings should be well and deeply prepared, and subsequent cultivation should probably be shallow, for the plants are shallow rooted. There are no cultivators known which are exactly suited to this crop. In the experimental work described in these pages an ordinary one-horse spike-tooth cultivator has been employed. The objection to this implement is that the framework is too large, interfering with the projecting branches of the plant, and also it is not easily regulated as to depth. Some tool of the nature of a one-horse

sweep which could be regulated so as not to go into the ground much more than 2 inches would be more serviceable. In the experimental plantation it has been the endeavor to cultivate just enough to keep down the weeds and prevent the ground from baking. To keep down the weeds thoroughly it has been necessary to go through the plantation occasionally with a hoe, knocking down such stray weeds as the cultivator did not reach.

TIME OF HARVESTING.

It is not the purpose of this paper to attempt to say how often it will be most profitable to harvest crops of prickly pear from established cultivated plantations. Experience in this matter, as in many others, has been too brief. All that will be attempted at the present time is to state what can be done with one definite plan of cropping.

Prickly pear has been considered a slow-growing plant, and indeed it is a slow grower under natural conditions, where it is obliged to compete with hardy grasses and other vegetation. In a previous publication[a] the opinion has been expressed that it will take five years to produce a crop on uncultivated lands in the vicinity of Eagle Pass, Tex., while in the same publication estimates made by ranchers give the period as from two to three years. There appears to be no reason at present for changing the first estimate for uncultivated lands, while it has been demonstrated that a crop can be profitably harvested in two years in cultivated plantations. Whether a proportionately greater yield can be secured by allowing the plants to grow three or four years has not been determined, but a paying crop can be secured at the end of the second year, and probably can be utilized at the end of eighteen months to good advantage if plantings are made in February or March. The first harvesting done upon the experimental tract was two years after planting. As shown in another place, there was at that time more than sufficient roughage upon an acre to feed two cows for one year.

But little fruit will be produced the first two years, but quite a large crop will usually be secured the third year.

METHOD OF HARVESTING.

The different methods of preparing prickly pear for the use of stock have been sufficiently discussed in other publications[b] and need not be repeated here.

In the singeing process economy depends largely upon the disposition of the plants. In the case of natural growth much time is

[a] Bulletin No. 74, Bureau of Plant Industry, "The Prickly Pear and Other Cacti as Food for Stock," 1905.

[b] Especially in Bulletin No. 74 of the Bureau of Plant Industry, pp. 12–20.

consumed in walking from one plant to another, because the plants are usually scattered over the field. Systematic planting economizes both time and fuel.

In the harvesting which has been done thus far upon the experimental plantations the torch has been used on standing plants, and cattle have then been turned on to graze them (Pl. II, figs. 1 and 2). Others have been cut down and hauled out of the field. This work was done in the spring of 1907. In the autumn of the same season little, if any, difference could be noticed between the growth made by the plants harvested by the two methods. Those plants grazed by the cattle, however, were left in a very ragged condition and consequently did not present so good an appearance. So far as growth is concerned, however, it must be admitted that grazed pear was nearly, if not quite, as good as that which was cut down and hauled off.

There are several methods of harvesting open to the grower, two of which have been mentioned here. Besides these methods the plants may be cut down before singeing, and, if desired, two rows may be cut into one center. The plants as they lie on the ground may then be singed. Again the plants may be singed as they stand in the row and then cut down, the cattle being allowed to graze them where they fall. It is quite possible that the best method is the last mentioned.

The singeing is done by pointing the blast flame downward in the center of the plant, because in this way the maximum surface is covered at one time by the flame. Afterwards the outer joints will be touched by the blast. These processes can easily be regulated so as to interfere but very little with the stump which is to be left standing. After the singeing the plants can be cut down and grazed where they fall. This will avoid leaving the stems partially chewed and macerated, in which condition they are more likely to decay and result in injury to subsequent growth. Of course the plants can be cut down before singeing, but the burning can not be done so advantageously after the plants are felled. When standing, both sides of the joints, which are in a more or less upright position, can be easily reached with the flame, while when felled the lower side in contact with the ground can not be so easily singed. The two most important requirements are economy of time and fuel and protection of the stumps which are to produce future growth. These requirements should be borne in mind constantly. Any process which economizes time and fuel and does not injure the stem is the one to use. It seems to the writer that singeing and then cutting the plants down to be grazed where they fall accomplishes this result best.

In some instances in the experimental investigations the harvesting has been close, leaving nothing of the old plant but the original cut-

ting. In other cases the harvesting has been done so as to leave all the joints directly attached to the original cutting. The latter plan leaves a stump of two to four joints. If the plant was established from a cutting laid on the surface of the ground, a large base and a good surface for future growth to spring from will be secured. There is no doubt that a large stump of this kind is an advantage; neither is there much doubt that these old stumps will produce a much heavier yield for the second biennial crop than is produced from the freshly established cuttings for the first crop. A considerably heavier growth was secured during the season of 1907 from plants having a stump of three or four joints from which to develop.

VARIETIES TO PLANT.

In the southern Texas region there are several native varieties of prickly pear, but in each locality there is usually one variety which predominates. The very fact that it does predominate is fairly good proof of its superior value for that locality.

In the vicinity of San Antonio the predominating variety is the typical form of *Opuntia lindheimeri* Englm., and this is the one which is considered the best of all the forms for cultivation in this immediate locality. Before any plantings were made upon the experimental tract a careful examination was made of the varieties in the neighborhood, and this one selected is the most promising. Subsequent results—for other varieties were also planted for comparison—confirmed the first judgment. There is no question that this is the most valuable of all the forms and species used. It has prominent and formidable spines, which turn white toward the end of the first season's growth, and abundant light golden spicules.[a] Another native variety with a trifle darker color, less formidable spines, and brown spicules has also made nearly as good growth and a much heavier crop of fruit. This may prove valuable. From 150 to 200 varieties have been planted. On the whole, none is to be recommended above the spiny native just mentioned. Some of the varieties planted, however, have characters which are decidedly advantageous.

One cultivated spiny form secured farther south is very promising for breeding purposes. It has withstood the climate the first two winters very well, but should another winter like 1904–5 occur it is certain to suffer badly, for it was cut back very severely then in the locality where secured. The spines on this one are not as formidable as on the native form that is being grown, and the spicules are almost

[a] See Bulletin No. 91, Bureau of Animal Industry, 1906, pp. 9–11, for further notes on this species.

entirely absent on the joints. This variety has made a growth at the rate of not less than 55 tons to the acre per annum during the past two years.

The prospective planter should study the plants in his locality carefully before planting. He should select that form which makes the largest and most rapid, clean growth, and from that variety he should choose the most healthy plants. Selection should be made first for vigor and second with reference to the habit of the plant. In southern Texas those forms growing most erect are to be preferred. In no case should a low, prostrate, or sprangling form be used. As compact a growth as possible is desirable on account of the greater ease with which such forms are singed and cultivated. An open-branching, low habit of growth renders the operation of cultivation very difficult on account of the interference of the branches with the animals and the machinery used in cultivation.

COST OF PLANTING.

During the spring of 1907 a careful record was kept of the cost of planting 6 acres of prickly pear upon the experimental plots. Owing to the requirements of the farm, men could not be employed regularly for full days on the planting and preparation of the ground, but so far as the value of the record goes it is considered that nothing is lost, for the time has been kept in hours for man and team.

The ground selected had never been plowed. It was in native grass, closely pastured for several years, and had been grubbed nearly clean of mesquite and other brush years ago. The greater part of the plowing and harrowing was done at odd times between the 1st of January and the 1st of March. The season being very dry considerable difficulty was experienced in getting the soil well pulverized, and even the plowing was done with much difficulty.

The stock used for planting was secured from various local sources, ranging from close by to 2 miles distant. The greater part of the stock, although it was practically all of the same variety, was hauled from a neighboring ranch 2 miles away. Some was cut from a pasture about half a mile distant, and about four loads from a smaller experimental tract planted two years ago contiguous to the present field.

The time employed in the various planting operations, exclusive of the preparation of the ground (plowing and harrowing), was as follows:

	Hours.
One man and team hauling stock (6 acres)	85
One man and team marking (6 acres) and covering (3 acres)	14
One man distributing cuttings (6 acres)	54

The laborers used in hauling were negroes and Mexicans, and the time was not employed to good advantage. It will be seen from the

above statement that the heaviest item of expense was for hauling the stock for planting, which ought to have been done, even under the disadvantages of distance, much cheaper.

Assuming the value of a man and a team at $3 and a man at $1 a day of ten hours, the cost of planting an acre after the ground is prepared is a little less than $6. If it is assumed that the value of the preparation for planting is $3 an acre, then it costs about $9 an acre to get the cuttings planted. With good labor advantageously employed this expense could doubtless be reduced to $6 or $7 an acre, but even at $9 the operation is not expensive when it is considered that a plantation is probably good for fifteen or twenty years and that subsequent planting or establishing plants is a simple matter when the material is on the ground and all that is necessary to establish a new plant is to lay a joint in firm contact with the soil.

SPINELESS COMPARED WITH SPINY SPECIES.

Much emphasis has been placed of late, especially in popular writings, upon the great advantages of spineless prickly pears. The spines of these plants leave an unpleasant memory. They are difficult to handle, and the novice usually can not conceive how the plants can be utilized at all on account of their formidable armament. It naturally follows that if spineless forms can be substituted the last objection to them has been removed. They could then be handled with bare hands, and eaten as they grow by all kinds of live stock. So firmly is the "spineless cactus" idea established in the public mind that much talk has been made about establishing such forms, even on the deserts, supplanting the native forms and producing an abundance of forage for live stock—this to be utilized without the singeing process to which the native spiny forms must be subjected.

While such ideas are very interesting and attractive, there are many practical considerations which must be taken into account. Of course, the experience of the writer is as yet meager, these experiments having been carried on only about four years. However, observation, together with three or four years' experimental evidence, while not conclusive, points strongly to certain conclusions which are not at all favorable to spineless forms for southern Texas, for the immediate future at least.

Thus far no spineless forms have been found which are hardy under the conditions existing at San Antonio. The writer has secured ten or twelve spineless forms from Mexico, and the Office of Seed and Plant Introduction of the Bureau of Plant Industry has imported for investigations as many more from Hawaii, southern Europe, and northern Africa, all of which have been planted and well cared for. All that are left of these spineless forms at the

present time are such individual plants as have been protected during the winter. There are a few nearly spineless forms here and there in southern Texas, but so far as has been observed none of them are quite hardy. They live through one or two winters all right, but may be frozen down badly the third winter. The nearest approach to hardiness that has been seen is in the city of Laredo, Tex. There are here a few plants (nearly spineless) which often pass the winter uninjured, but they were frozen to such an extent in February, 1904, that not less than one-half of the joints broke off. Even these are not hardy upon the plantation at San Antonio and probably would suffer nearly every winter at Laredo were the plants there not protected by surrounding buildings.

Lack of hardiness renders the spineless forms of no economic value at the present time in southern Texas. If they can not withstand the winter temperature it is of course useless to plant them. But while this is true it is not at all improbable that these smooth forms may in time become very important and possibly entirely supplant in culture those forms which are now being grown. The bringing about of such a condition is, however, a long and tedious process which will involve years of breeding in which the farmer can usually take little or no part. Work along this line is now being conducted for the benefit and use of the future, but *present results must be secured from spiny natives.* Of course, in experimental work sight is not lost of the fact that economic conditions may change in the future so that it will be advisable to have spineless forms, but the whole question is one of production. If spineless forms which are hardy and which will produce more feed than spiny species which are now being grown can be evolved they will be valuable in proportion to the excess of feed which they will produce. This is as yet a purely experimental field, but the spiny native varieties have been proved to be valuable.

Aside from lack of hardiness, the spineless prickly pears have other disadvantages. Wherever grown they have to be fenced. It will be obviously impossible to grow them in uncultivated pastures, even in regions where they are hardy, for they would be grazed too closely, if not exterminated in a very short while. Fences are expensive. Unless the area planted to these forms were very large, which it could not be for some time, a rabbit-proof fence would be required. This sort of fence has been found necessary in order to protect the varietal plantings made by the Bureau of Plant Industry at San Antonio. Spineless forms would be severely injured by rabbits, gophers, and rats. The latter often do considerable injury to the spiny native plants, but the spineless forms would suffer very severely. A planting of about a hundred cuttings of imported varie-

ties, not all spineless, was completely destroyed in a fortnight by rabbits in southern Arizona two years ago. When a large acreage is planted the danger from these pests will not, of course, be so seriously felt, but it will be many years before any extended plantings of spineless forms can be made. There is not enough stock of spineless prickly pears in this country at the present time to plant 5 acres if it were all gathered into one place.

A plantation of spineless prickly pear would not only have to be fenced, but stock could not be allowed to enter the field at any time of the year, for they would trample over the entire field, knocking down plants hither and yon and causing an unwarranted waste. All of the crop would have to be harvested, loaded on wagons, and hauled to another lot to be fed. Remembering that 100 pounds a day will be eaten by an average cow, it will be seen that this procedure will mean considerable expense. In a 100-cow dairy it will mean the moving of 5 tons of material for feed each day, besides the removal of the manure. On the other hand, the spiny forms, singed and fed where they stand, obviate this expensive handling and cause the manure for 100 cows to be distributed each day on about one-fifteenth of an acre—by no means a small item in maintaining fertility. With spiny forms the number of plants fed or grazed each day is absolutely within the control of the rancher, even though stock is allowed in the field all of the time.

So far as southern Texas is concerned the advantages of the spineless and spiny prickly pears concerning which we have any knowledge may be summed up as follows:

Advantages of spiny native forms.	*Advantages of spineless forms.*
1. They are hardy.	1. They do not require singeing.
2. They do not require fencing.	
3. They are injured but little by wild animals.	
4. They require a minimum of handling.	
5. They accomplish the distribution of the manure during the day.	

QUANTITY OF FEED PRODUCED BY PRICKLY PEARS.

Our knowledge of the yield of prickly pear, either under natural or cultivated conditions, is as yet quite imperfect, and the statements made herein with reference to yields are made with such reservation as is consistent with the meagerness of the evidence. However, it is believed that all computations in whatever manner made are exceedingly conservative, and underestimate rather than overestimate in every case what may be secured from a cultivated crop of prickly pears.

The first plantings at San Antonio, and, indeed, the first attempt ever made in this country to cultivate this plant as food for stock so far as the writer is aware, occurred in February, 1905. A plot of ground 416 feet long and 208 feet wide (2 acres) was secured under lease the preceding winter. Half of this area was plowed and put in a good state of cultivation, the other half being left in the condition in which it was found, i. e., in native sod, with all brush removed. One half of the cultivated portion (one-half acre) was reserved for varietal plantings and the other half was planted to three or four varieties of native species, the typical *Opuntia lindheimeri* predominating over all others. The whole area was laid off into 6-foot rows, numbered 1 to 69, and all plantings have been made on this plan, variation being made in the distance apart of the plantings in the row only.

Early in March, 1907, when the plantation was 2 years old, the first harvesting was made. No weights were obtained except on a small scale—too small, in fact, to make a reliable record, and consequently need not be reported upon here. In one instance 75 head of stock were turned in to graze off two rows which had been singed. As nearly as could be estimated this number of cows got from this small area a full day's ration of roughage. There were some young cows among them, and some which did not eat pear as freely as they should, but nevertheless they had been fed prickly pear regularly all the winter and were still receiving it daily. Accepting the above as the measure of the biennial production of forage of this plant under cultivation, it will readily be appreciated that at this rate 2 acres of this crop would, roughly, supply roughage for 75 cows for one month, and 25 acres would, roughly, supply their needs for one year, but as it took two years to grow this crop, on this basis it would require only 50 acres to furnish rough feed for 75 cows continuously. It is recognized that this is a very crude and imperfect estimate of production, but it is, nevertheless, instructive when taken in connection with what the eye can see of the 2-year-old crop shown in Plate II, figure 4. In order to put the matter very conservatively, suppose this area was increased 50 per cent: this would mean that 75 acres would furnish 75 cows with continuous roughage. This is still a production equaled by that of few areas in the country. This quantity was produced during one very favorable and one very unfavorable season and probably represents about the average crop.

More definite data upon production were secured early in October, 1907, when the plantation was 31 months old. At this time two rows were selected near the east side of the native plantings on cultivated ground because they were thought to be typical of the half acre of the cultivated native *Opuntia lindheimeri*. These rows were har-

vested down to the original cutting and weighed. These two rows, numbered 20 and 21 in the records, yielded 8,518 pounds. Rows 35 and 36 were then harvested, and weighed in the same manner. Row 36 was considered the poorest in the area. This was in part due to its being in close proximity to uncultivated ground and in lesser part to the ravages of the red spider. These rows were taken in order to be certain not to overestimate the production. These two rows yielded 7,269 pounds. On the four rows, therefore, there were produced 15,787 pounds. The area occupied by them measures three twenty-sixths of an acre. The yield to the acre, consequently, was 136,820 pounds, or 68⅔ tons. On account of the time of the year at which the measurements were made it is rather difficult to reduce this thirty-one months' growth into yearly terms, but if it is assumed that three years' growth was secured an average yearly production of 22⅘ tons of green, succulent forage is shown.

This estimate of the average growth per annum of 22⅘ tons is certainly conservative. It is evident that the growing season is not closed the 1st of October, but, on the other hand, that a very decided increase will occur between that time and February. Again, the measurements were made at the close of a long dry season. It is quite certain that the growth for the remaining five months, together with the water absorption of the humid winter season, would be expressed by tons to the acre. Besides this growth of plant body, there was produced during the third growing season between 4 and 5 tons of fruit to the acre. This fruit is greatly relished by horses, cattle, sheep, and swine, and is harvested by them without assistance and without injury to the plants.

In feeding dairy cattle[a] at San Antonio it was found that a complete roughage ration of prickly pear consisted of about 140 pounds for each cow daily. In feeding steers for market at Encinal, Tex., an average of about 75 pounds was eaten daily by each steer. These figures would indicate that 100 pounds is about what the average animal will eat in a day. But the yields previously stated show that sufficient roughage is grown here on an acre for about one and one-fourth animals.

Any way it is figured, roughage of prickly pear for one mature bovine animal on an acre seems to be a very conservative estimate.

CULTIVATION AND NONCULTIVATION.

At the same time that estimates were made of the rate of growth on cultivated ground rows 37 and 38 were harvested. These were grown without cultivation. As stated elsewhere, a furrow was opened

[a] Bulletin No. 91, Bureau of Animal Industry, 1906.

in the native sod, the joints laid against the land side, and the dirt pulled back over their bases. The growth of pear on these two rows in thirty-one months weighed 980 pounds. This is at the rate of 8.49 tons to the acre. Reducing this to terms of annual growth in the same manner as was done in the other case, we have 2.83 tons to represent the growth per annum upon uncultivated ground; in other words, eight times as much forage was produced under cultivation. (See Pl. I, fig. 1.)

The method of planting insured the rooting of the cuttings practically the same upon uncultivated as upon cultivated land. Practically every cutting in either situation rooted and grew through the period specified.

It should be noted that the plantation is under fence. The prickly pear upon the uncultivated ground, therefore, had to compete with its full complement of grass growth. It would have made a greater gain if the grasses were grazed off, as they commonly are in the native pastures of the region. The figures showing the relation of the production under the two conditions are consequently not comparable with what would take place in pasture-grown pear. Indeed, the growth in Mr. Sinclair's pastures just outside of our fence was very much greater than that upon our uncultivated area. This furnishes a very strong suggestion as to the cause of the increase of prickly pear in some sections of southern Texas since its occupation and settlement. Formerly, when grasses were not grazed so closely, they were stronger competitors of the prickly pears than they are now and were able to keep it in check. Overgrazing, coupled with the prevention of fires, is doubtless responsible for the excessive growth of prickly pear in some sections of the region. On the other hand, the rapid increase of mesquite and other brush tends to check the growth of the pear, for it does not thrive in the shade.

SOME EFFECTS OF CULTIVATION.

During the year 1907 the drought from June to October 1 was much more pronounced than the average for this section. The prickly pear in the pastures surrounding the experimental plantings, as a consequence, was suffering considerably by the 1st of October. Nearly all of it was somewhat shriveled, and in a few instances the color had begun to change, showing the beginning of interference with metabolism. Upon the cultivated area, on the contrary, the long period with little precipitation had no apparent effect. All plants were thrifty and vigorous. It is believed that no particular injury would have resulted if no rain had occurred for another three months.

The effect of cultivation upon the development of spines is naturally of some interest, and since the writer has often been questioned regarding the comparative spininess of cultivated and uncultivated plants, a few remarks upon the subject are made, with, however, no attempt at any generalization. In the case of the typical form of *Opuntia lindheimeri*, which is being grown in the experiments, there is a decided increase in spininess under cultivation. Indeed, the entire plant looks somewhat different when cultivated; that is, a plant under favorable conditions is just as different from a plant growing under unfavorable conditions in this species as in the common cultivated crops. A comparison of Plate II, figure 3, with Plate II, figure 4, will tell better than words what the differences are. The first is a view of the Poor plantation, which, although planted originally, is in a practically native condition, for it was never cultivated. It will be readily seen that the spines are fewer by several fold upon the uncultivated plants. No quantitative measurements have ever been made, and consequently only general statements are possible at this time.

USES OF THE CROP.

A more or less complete discussion of the uses to which prickly pear is put will be found in Bulletin No. 74 of this series, and a further discussion of the value of the crop is contained in Bulletin No. 91 of the Bureau of Animal Industry of this Department.

The crop appears especially adapted to dairy purposes because of the comparative ease with which the ration can be balanced by the addition of concentrates, which are used with all roughage in this region. The succulence appears to be a decided advantage, and of course can be obtained at any time of the year if the plants are grazed where standing or are harvested as fed. The importance of this can not be overestimated, for it applies to all seasons of the year, and oftentimes green feed for dairy cattle is as difficult to secure in the summer as in the winter. There is an impression in some sections that this feed can not be used after the new growth starts in the spring, but this is entirely disproved by the practices of several ranchers who have used it at all seasons of the year with good results. Of course there is a period during which the young growth will not be eaten on account of its being distasteful to animals,[a] and this growth will therefore be wasted at that time, but there is no season of the year when pear will not be readily eaten, especially if other feeds are short or dry.

It is very probable that the crop can also be used successfully for the production of baby beef, as has been suggested by Mr. Sinclair,

[a] See Bulletin No. 91, Bureau of Animal Industry, 1906, p. 17.

who has fed pear with as great success as anyone in southern Texas. This region has been a favorite breeding ground for many years, and much beef is constantly prepared for market, a large part of which is accomplished by the use of prickly pear at some stage of its growth. The great drawback in any beef production—especially in the production of baby beef—is a lack of continuity of feed. An abundance of pasture is to be had in some seasons, but in other seasons it is too short for the maintenance of a steady rapid growth. A roughage like this, therefore, which can be utilized at any season and is a sure crop, fills a gap not filled by any other.

Prickly pear roughage is relished by nearly all kinds of live stock. No case is known of horses being fed on it, but other classes of stock eat it readily. Cattle, sheep, goats, and swine relish it, and even chickens utilize it when it is chopped for them. Hogs will eat even stumps and heavy joints that cattle leave.

In short, it can be said that prickly pear is of vastly more importance in southern Texas than is ordinarily appreciated. A crop which will produce twenty-odd tons of roughage to the acre per annum with a degree of certainty not attained by any other, and this readily eaten by all classes of live stock, is not to be disregarded as an important farm crop even if it has been looked upon as something of a nuisance in the past.

PRICKLY PEAR COMPARED WITH SORGHUM.

Upon another page it has been shown that 22⅘ tons of prickly pear can be grown each year upon the gravelly-black-waxy soils of the San Antonio region of Texas. The main hay crop upon the ranch where the experiments are conducted has always been sorghum, and since the experiments were started this has been placed in a silo. In the season of 1906 about 1 ton of silage was secured to the acre, and in 1907 about 2½ tons. These are estimates made in the silo.

In feeding tests upon the ranch in 1905 it was found that 6 pounds of prickly pear produced the same results in feeding dairy cattle as 1 pound of dry sorghum hay.[a] If 1 ton of hay is assumed to be equivalent in feeding value to 3 tons of silage, then the hay production from sorghum has been on an average for the past two years only seven-twelfths of a ton to the acre per annum. This seven-twelfths of a ton of hay, assuming the relative value of sorghum hay to prickly pear to be as 6 to 1, is equivalent to only 3½ tons of pear. In other words, prickly pear has produced more than six times as much roughage during the past two years as sorghum. Of course, the yield of sorghum mentioned here is abnormally small, but seasons occur every now and then in this region when crops are short,

[a] See Bulletin No. 91, Bureau of Animal Industry, 1906, p. 4.

and while they may be assumed to be at the lowest point of production during these two years it is against these years of shortage that it is necessary to provide.

ENEMIES OF THE PRICKLY PEAR.

There are many fungus and insect enemies of the prickly pear, but only one insect and one fungus need be considered in this place because the others have not thus far given cause for any apprehension.

The black-spot fungus (*Perisporium wrightii*) is first found as a soft, brownish area, usually more or less circular, on any portion of the joint. This soon becomes black and rotten, and later dries up when the ascogenous bodies appear upon the epidermis. Often there may be a dozen of these spots on a single joint, and these are approximately one-half to 1 inch in diameter usually and extend clear through the joint. When but one or two occur the joint may recover, the tissue healing up around the diseased portion, when the dried diseased tissue falls out, leaving a notch or a clear circular opening through the joint. When the diseased spots are numerous, the plants are very much impoverished and the joints often drop off, the healing in this case occurring at the union between them.

Fortunately this disease appears less prevalent upon plants under cultivation. In February, 1905, when the first plantings were made, one row, 208 feet long, was planted to very badly diseased pear in order to study the behavior of the disease. There are at present some diseased plants upon this row, and many of the cuttings failed to grow, but the vast majority of the plants have overcome the disease quite perfectly. It is much more common on some varieties than on others, and the badly diseased material which was planted was discovered later to be of a different variety from that which it is recommended should be planted in the vicinity San Antonio. The typical form of *Opuntia lindheimeri* which is recommended is much less subject to this disease than some of the other native forms. It is a common disease in many species of prickly pear throughout the pear region from Texas to the city of Mexico.

The only practical remedy is to feed the diseased plants and propagate from healthy stock only. At the present time it looks as though this method of handling would reduce the injury to a minimum. The cultivated area referred to, except where diseased pear was planted, is quite free from disease now. The stock was carefully selected, however, and there appears to be no disease on either the cultivated or uncultivated areas.

The red spider (*Tetranychus opuntiae*), on the contrary, is more serious upon cultivated than upon uncultivated land. These minute

animals work around the areoles of spines and spicules first and gradually cover the entire surface of the joint. After they have worked on the pear, a yellowish or brownish dead callus forms over the entire surface. This cracks in places and there is often a considerable exudation of mucilage, which, although white at first, finally turns black. The plants are very much disfigured by this mite, but it can not be stated at present just how much real injury is done, for no plants have been observed which have been killed by it.

It may be difficult for the uninitiated to recognize what the trouble with the plants really is, but after seeing it or having it pointed out it can not be overlooked, for the diseased condition is very characteristic. It is not so easy to find the mites, however, because they are very small and at times nearly, if not quite, absent.

Just what their habits are during the season has not been worked out. It is certain that they were abundant in March, 1907, and less abundant in the autumn of the same year.

The Mexicans are very familiar with this diseased condition, but so far as known have not interpreted the cause. Attention has been called to it several times by Mexican ranchers, who deplored its presence and expressed the opinion that it might in time entirely destroy such forms as nopal amarillo, naranchado, chaveño, and certain forms of joconoxtle. While these fears express extreme views, there is no doubt that the red spider is a pest to be reckoned with. However, in Mexico, as in the United States, the greatest injury is done when plants are close together or growing intermingled with other shrubbery. This crowding together of the plants is probably the cause of the large numbers of mites which developed in our cultivated experimental area.

Experience is altogether too limited yet to permit much, if anything, to be said with any certainty about this injurious insect. A few observations, however, may be of interest. These, concisely tabulated, are as follows:

(1) The disease occasioned by the red spider has long been known, but its cause has only recently been determined.

(2) It has never been alarmingly abundant upon the uncultivated pear in southern Texas.

(3) At the end of the second year a few red spiders appeared in our plantation.

(4) During the third season these mites multiplied rapidly and did considerable injury to the older plantings.

(5) All plants harvested in any manner whatsoever in the spring of 1907 were uninjured by the red spider during the season, although some of them were badly infested when harvested.

(6) No red spiders were found during the season on plantings made in the spring of 1907.

(7) The red spider has been abundant upon thick plantings only, and no injury has been done any of the plants except the natives thus far.

(8) Red spiders are injurious only part of the year. In 1907 they were abundant in March.

(9) Heavy rain washes the red spiders off and they do not appear to regain possession for some time, but just how long has not been determined.

(10) Prickly pear having red spiders on it is eaten as readily by live stock as that which is not affected.

The above observations indicate that the red spider can be kept in check by feeding such areas as are affected as they appear. The fact that the crowding together of the plants seems to increase the spread of the red spiders and the injury done may influence the method of planting.

Another malady which is of very common occurrence can probably be discussed here as well as elsewhere, because it is commonly looked upon as a disease. This occurs some time in the spring of every year at San Antonio. It is a condition in which the new joints of the plant drop off when about half grown. The recovery from its effects is very rapid, but of course the growth which drops off is lost.

To illustrate the extent of this malady, a single case in which a quantitative estimate was made can be mentioned. About the middle of May, 1905, a large plant harvested during the winter of 1903-4 had just recovered from the effects of this malady. It had made a splendid growth the previous season and had started vigorously again when the joints began to drop off. At the time referred to most of the fallen joints were completely dried. Fifty-two of them were lying at the base of the plant, while eleven more were partially injured. In spite of this, the plant had completely recovered and was then supporting, besides the eleven somewhat injured joints still clinging to it, fifty-eight perfectly sound and normal ones. What proportion of the latter started after the falling of the first crop of joints can not be stated, but probably nearly all of them. This was a large, vigorous plant (second growth) from an old stump harvested several times, and probably represents an extreme case, but it is not uncommon for one-half to two-thirds of the first crop of joints to be lost in this way at San Antonio.

The exact cause of this particular phenomenon has not been demonstrated, but it appears to be due to neither fungous nor insect enemy, but, on the contrary, to be purely climatic. Observations seem to indicate that the falling of the joints takes place some time

after a cold and usually a moist spell of weather which occurs when the joints are about half grown and while they are thin and leathery, before they have begun to swell out into the normal shape of the mature joint.

In 1907 this malady was at its height about April 27. At this time nearly all the season's growth on many species was destroyed, and in some none remained. In others about half fell off, while a very few varieties were uninjured. The native *Opuntia lindheimeri* was not much affected; possibly one-eighth of its joints were injured, but not more than this. All varieties recovered speedily, putting out new joints in a short time. No injury was done to the previous year's growth.

While often a large part of the growth of a month or so in the spring is lost in this way, no apprehension is felt regarding the matter in respect to the yield. In fact, the yields which are reported elsewhere in this paper have been produced each year in spite of this malady.

SUMMARY.

These experiments in planting prickly pear as a farm crop have been conducted in a region having a rainfall varying from $15\frac{9}{10}$ inches to $40\frac{1}{2}$ inches a year, the average for the past eighteen years being $28\frac{2}{5}$ inches, but this rainfall is very unevenly distributed.

The absolute minimum temperature for the locality is 4° F., but this is exceptionally low, having occurred but once in eighteen years. During the ten years ended in 1903 there was only one year which had seven days with a minimum below 22° F., two years had none lower than 22° F., while the others had from one to six days during the year with a minimum temperature lower than 22° F.

The plants are most advantageously grown from single-joint cuttings, which are easily prepared by cutting up all of a full-grown plant into single joints with a spud or spade.

Plants should be established about 2 feet apart in 6-foot rows.

When the ground is moist and well prepared, cuttings can be distributed on the surface of the ground. When these conditions are not met the cuttings should be placed in a furrow and partially covered with another furrow. With care a sulky cultivator can be used for covering the joints.

Planting may be done at any time of the year except during the hottest and driest part of summer.

Cultivation should be shallow and sufficiently frequent to keep down weeds and prevent excessive baking of the soil.

Plants set in February can be harvested at any time of the year after twenty to twenty-four months.

It is believed that it will be found advantageous in harvesting to singe the standing plants and then cut them down to be grazed. However, good results have been obtained without cutting. It is possible to singe after cutting, but it is a little more difficult and will probably be attended with more waste.

It will be advantageous in harvesting to leave a stump of two to four joints rather than to harvest too closely.

Those forms which are most vigorous and most free from disease should be selected for stock to plant. In the vicinity of San Antonio this is the typical form of *Opuntia lindheimeri.*

The experimental plantation cost nearly $9 an acre, including all expenses, beginning with the breaking of the raw prairie and ending with the cuttings properly placed. With good labor and proper management this expense, it is believed, could be reduced to $6 or $7 an acre. Even $9 per acre is low for a plantation that does not require renewing for fifteen or twenty years.

The spineless forms thus far grown (about twenty varieties) are practically useless under present conditions in Texas except for breeding purposes.

A conservative estimate of the annual production of prickly pear under cultivation is 22⅕ tons, or enough roughage for one bovine animal for a year from each acre of ground. This is to be harvested biennially.

Cattle, sheep, goats, swine, and even chickens will eat the crop readily at any time of the year.

Eight times as much growth of prickly pear has been secured under cultivation as was obtained without cultivation in ungrazed pastures.

More than six times as much roughage (actual feeding value) has been secured during the past two years from prickly pear as from sorghum.

One fungous and one insect enemy of prickly pear of some importance are found, both of which may be controlled either by selection of stock or by methods of harvesting, or by both combined.

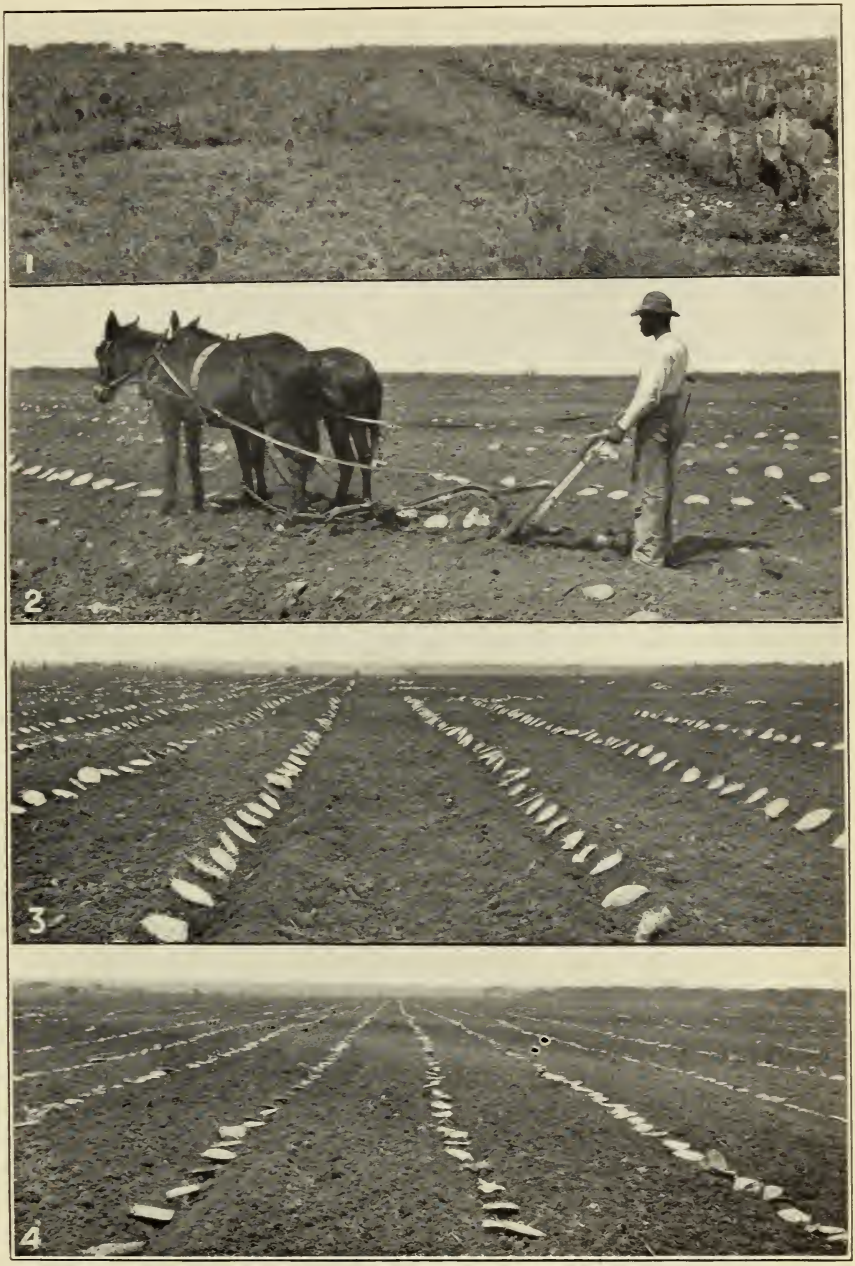
The diseased condition known as dropping of joints is believed to be purely climatical. This, while costing a month's growth in the spring, is not looked upon with any apprehension. The yields given in this paper have been secured in spite of this injury.

PLATES.

DESCRIPTION OF PLATES.

PLATE I.—Prickly pear experiments. Fig. 1.—Cultivated and uncultivated prickly pear, showing relative growths. The first two rows cultivated and the first two rows uncultivated were planted in the same way and at the same time. The vegetation in the uncultivated area consists of native grasses and the broom weed (*Ampheacharis dracunculoides*). Fig. 2.—Covering the cuttings with a plow. Covered in this way they usually stand at an angle of about 45 degrees. Fig. 3.—Cuttings distributed in the furrow ready to be covered. When covered with a plow they stand at about the angle shown, but if a sulky cultivator is used to cover them they can be arranged nearly upright. In the distance will be seen piles of cuttings ready to be distributed. Fig. 4.—Cuttings distributed on the surface of the ground. These are not to be covered, but will grow readily in this position. This method of planting is to be recommended when the ground is thoroughly prepared and sufficiently moist.

PLATE II.—Prickly pear experiments. Fig. 1.—Cattle grazing singed prickly pear on the experimental plantation, March, 1907. Fig. 2.—Singeing 2-year-old pear upon the experimental plantation in March, 1907. Fig. 3.—Uncultivated plantation 20 years old upon the Poor ranch, at San Antonio, Tex. This plantation has been repeatedly harvested but never cultivated. Fig. 4.—Cultivated prickly pear 2 years old upon the experimental plantation. Compare the appearance of the plants with the same variety shown in figure 3.



PRICKLY PEAR EXPERIMENTS.

FIG. 1.—CULTIVATED AND UNCULTIVATED PRICKLY PEAR. FIG. 2.—COVERING CUTTINGS WITH A PLOW. FIG. 3.—CUTTINGS DISTRIBUTED IN FURROW READY TO BE COVERED. FIG. 4.—CUTTINGS DISTRIBUTED ON THE SURFACE OF THE GROUND, NOT TO BE COVERED.

PRICKLY PEAR EXPERIMENTS.

FIG. 1.—CATTLE GRAZING SINGED PRICKLY PEAR. FIG. 2.—SINGEING PRICKLY PEAR. FIG. 3.—UNCULTIVATED PLANTATION TWENTY YEARS OLD. FIG. 4.—CULTIVATED PRICKLY PEAR TWO YEARS OLD.

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